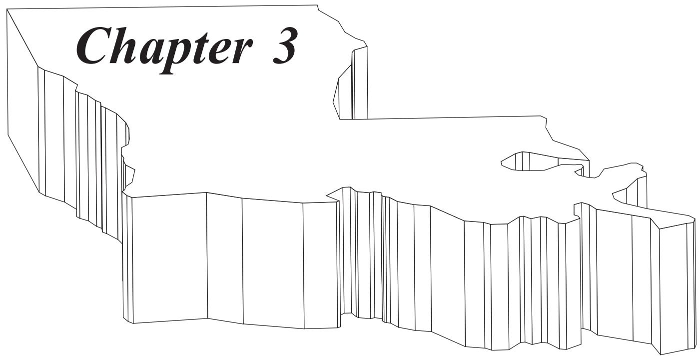


The House As A System

We sometimes think of our homes as independent structures, placed on an attractive lot, and lived in without regard to the world around. Yet, most homes have problems — some minor nuisances, others life-threatening:

- ❒ Mold on walls, ceilings, and furnishings
- ❒ Mysterious odors
- ❒ Excessive heating and cooling bills
- ❒ High humidity
- ❒ Rooms that are never comfortable
- ❒ Decayed structural wood and other materials
- ❒ Termite or other pest infestations
- ❒ Fireplaces that do not draft properly
- ❒ High levels of formaldehyde, radon, or carbon monoxide

These problems occur because of the failure of the home to properly react to the outdoor or indoor environment. The house should be designed to function well amid fluctuating temperatures, moisture levels, and air pressures. Quality builders are concerned about these problems, but are not always certain what steps to take to prevent them. They must start by considering what makes buildings healthy and comfortable.

Health and Comfort

The following factors define the quality of the living environment. If kept at desirable levels, the house will provide comfort and healthy air quality.

- ❒ Moisture levels — often measured as the relative humidity (RH). High humidity causes discomfort and can promote growth of mold and organisms such as dust mites
- ❒ Temperature — both dry bulb (that measured by a regular thermometer) and wet bulb, which indicates the amount of moisture in the air. The dry bulb and wet bulb temperatures can be used to find the relative humidity of the air
- ❒ Air quality — the level of pollutants in the air, such as formaldehyde, radon, carbon monoxide, and other detrimental chemicals, as well as organisms such as mold and dust mites. The key determinant of air quality problems is the strength of the source of pollution
- ❒ Air movement — the velocity at which air flows in specific areas of the home. Higher velocities make occupants more comfortable in summer, but less comfortable in winter
- ❒ Structural integrity — the ability of the materials that make up the home to create a long-term barrier between the exterior and inside

CONCEPTS

Heat Flows in Homes

Heat transfer — heat loss and heat gain — between a home and its exterior envelope has a major impact on health and comfort. The sidebar explains the three primary modes of heat transfer.

When building energy efficient homes, many builders focus on reducing conduction heat gain and loss by installing more insulation. However, as shown in Table 3-1, air leakage and duct leakage are serious contributors to heating and cooling bills. They can also create moisture and indoor air quality problems. Unfortunately, many homes labeled as energy efficient have no provisions for sealing air leaks or duct leaks.

In summer, cooling needs are driven by the location and shading of windows. Also, the percentage of the cooling load that is for *latent cooling* (humidity removal) can increase substantially in homes with well insulated thermal envelopes. The major sources of moisture include cooking activities, human respiration and perspiration, and infiltration of hot, humid, exterior air. Therefore, tighter homes can be less humid in summer.

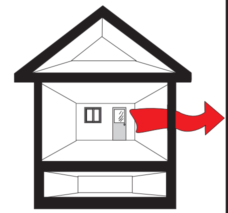
Table 3-1
Contributors to Heating and Cooling Bills in a Typical Home
(% of Total Energy Bill for Typical New Homes)*

	Heating	Cooling
Ceiling	4-8%	4-8%
Walls	5-9%	4-6%
Windows	9-12%	4-7%
Floors	5-9%	0-2%
Air Leaks (including humidity gain)	30-40%	20-30%
Duct Leaks	10-30%	10-30%
Solar Gain		10-15%
Internal Gain		3-6%
Latent Cooling		20-35%

* Percentages will vary according to the local climate, choice of energy source, and building design.

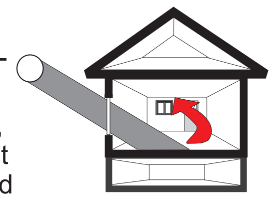
Figure 3-1
How Heat Moves

Conduction



- ❒ The transfer of heat through solid objects, such as the ceiling, walls, and floor of a home.
- ❒ Insulation (and multiple layers of glass in windows) reduce conduction losses.

Convection



- ❒ The flow of heat by currents of air.
- ❒ As air becomes heated, it rises; as it cools, it becomes heavier and sinks.
- ❒ The convective flow of air into a home is known as *infiltration*; the outward flow is called *exfiltration*. In this publication, infiltration and exfiltration are known together as *air leakage.*

Radiation

- ❒ The movement of energy in waves from warm to cooler objects across empty spaces.
- ❒ Examples include radiant heat traveling from:
  - ❍ inner panes of glass to outer panes in double-glazed windows in winter.
  - ❍ roof deck to attic insulation during hot, sunny days.
- ❒ Can be minimized by installing reflective barriers; examples include radiant heat barriers in attics and low-emissivity coatings for windows.

Air Leaks and Indoor Air Quality

Both building professionals and homeowners have concerns about indoor air quality. It is important to understand that few studies on the subject have shown a strong relationship between indoor air quality and the air tightness of a home.

The major factor affecting indoor air quality is the level of the pollutant causing the problem. Thus, most experts feel that the solution to poor indoor air quality is removing the source of the pollution. Building a leakier home may help lessen the intensity of the problem, but it will neither eliminate it, nor necessarily create a healthy living situation.

Air leaks often bring in air quality problems from outside, such as:

- ❐ Mold from crawlspaces and outdoors
- ❐ Radon, while rare in Louisiana, entering from crawlspaces and under-slab areas
- ❐ Humidity from crawlspaces and outdoor air
- ❐ Pollen and other allergens from outdoor air
- ❐ Dust and other particles from crawlspaces and attics

The best solution to air quality problems is to build a home as tightly as possible and install an effective ventilation system that can bring in fresh, filtered outside air (not crawlspace or attic air) under the control of the homeowner.

Figure 3-2
Air Quality Problems from "Fresh" Air

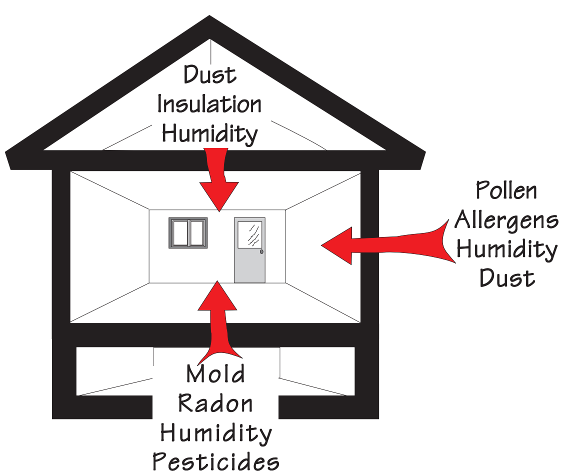
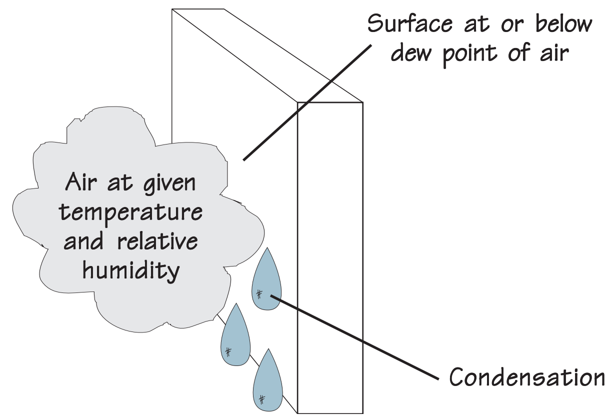


Figure 3-3
Conditions for Condensation



How Condensation Occurs

Air is made up of gases such as oxygen, nitrogen, and water vapor. The amount of water vapor that air can hold is determined by its temperature. Warm air can hold more vapor than cold air. The amount of water vapor in the air is measured by its relative humidity. At 100% RH, water vapor condenses into a liquid. The temperature at which water vapor condenses is its dewpoint.

$$RH = \frac{\text{the amount of water vapor in the air at a given temperature}}{\text{the maximum amount of water vapor that air can hold at that temperature}}$$

The dew point of air depends on its temperature and relative humidity. A convenient tool for examining how air, temperature and moisture interact is the Psychometric Chart, explained in the sidebar *Understanding Relative Humidity.*

Preventing condensation involves reducing the RH of the air, increasing the temperatures of surfaces exposed to moist air, and blocking the flow of moisture using air barriers and vapor barriers. However, builders should also allow spaces that might trap moisture to have drying potential — the ability to shed or reject moisture.

MOISTURE AND RELATIVE HUMIDITY

A psychometric chart aids in understanding the dynamics of moisture control. A simplified chart shown in Figure 3-4 relates temperature and moisture. Note that at a single temperature, as the amount of moisture increases (moves up the vertical axis), the relative humidity of the air also increases. At the top curve of the chart, the relative humidity reaches 100% — air can hold no additional water vapor at that temperature, called the *dew point*, so condensation can occur.

Winter Condensation in Walls

In a well built wall, the temperature of the inside surface of the sheathing will depend on the insulating value of the sheathing and the indoor and outdoor temperatures.

Example: When it is 35°F outside and 70°F at 40% relative humidity inside:

- ❑ The interior surface of plywood sheathing will be around 39°F.
- ❑ The interior surface of insulated sheathing would be 47°F.

The psychometric chart can help predict whether condensation will occur:

1. In Figure 3-5, find the point representing the indoor air conditions.
2. Draw a horizontal line to the 100% RH line.
3. Next, draw a vertical line down from where the horizontal line intersects the 100% RH line.

In the example, condensation would occur if the temperature of the inside surface of the sheathing were at 44°F. Thus, under the temperature conditions in this example, water droplets may form on the plywood sheathing, but not on the insulated sheathing.

Summer Condensation in Walls

Figure 3-6 depicts a similar case in summer. If the interior air is 75°F, and outside air at 95°F and 40% relative humidity enters the wall cavity, will condensation occur on the exterior side of the drywall, which would be about 73°F? Using the psychometric chart, we find that the dew point of the outside air leaking into the wall cavity would be about 67°F. Since the drywall temperature is greater than the dew point, condensation should not form.

Figure 3-4
Psychometric Chart

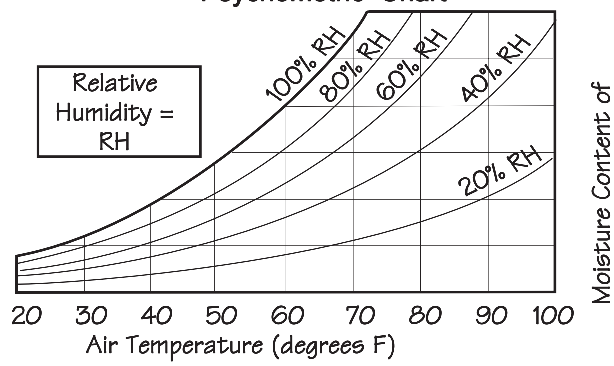


Figure 3-5
Winter Dewpoint Temperature Inside Walls

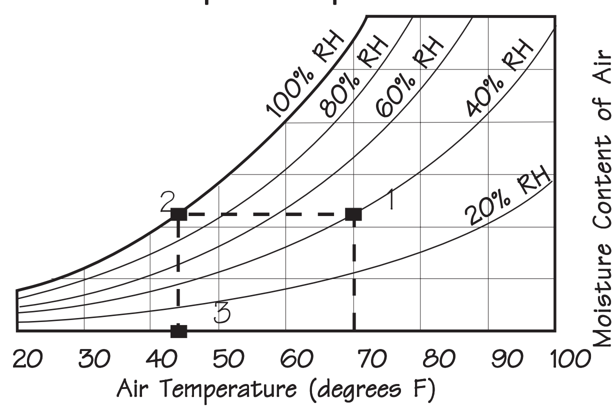
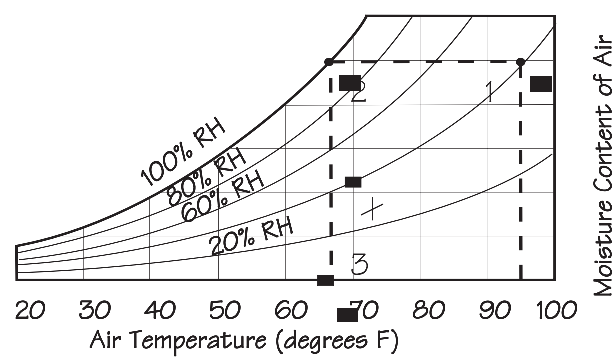


Figure 3-6
Summer Dewpoint Temperature Inside Walls



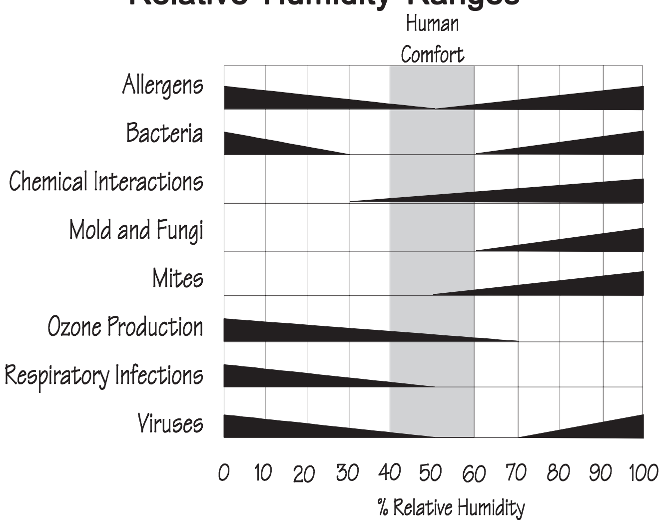
Affect of Relative Humidity

Humans respond dramatically to changes in relative humidity (RH):

- ❑ At lower RH, we feel cooler as moisture evaporates more readily from our skin.
- ❑ At higher levels, we may feel uncomfortable, especially at temperatures over 78 degrees.
- ❑ Dry air can often aggravate respiratory problems.
- ❑ Mold and fungi grow in air over 70% RH.
- ❑ Dust mites prosper at over 50% RH.
- ❑ Wood decays when the RH is near or at 100%.
- ❑ Humans are most comfortable at 40% to 60% RH.

Figure 3-7 shows that relative humidities in the 40% to 60% range accomplish two major goals: provide human comfort and minimize the many diverse negative impacts that occur in drier and more humid air. By controlling air leakage and properly designing HVAC systems, relative humidities should remain at desirable levels.

Figure 3-7
Relative Humidity Ranges



Systems in a Home

Whether the health and comfort factors of temperature, humidity, and air quality remain at comfortable and healthy levels depend on how well the home works as a system. Every home has systems that are intended to provide indoor health and comfort:

- ❒ Structural system
- ❒ Moisture control system
- ❒ Air barrier system
- ❒ Thermal insulation system
- ❒ Comfort control system

Structural System

The purpose of this book is not to show how to design and build the structural components of a home, but rather to describe how to maintain the integrity of these components. Key problems that can affect the structural integrity of a home include erosion, roof leaks, water absorption into building systems, excessive relative humidity levels, fire, and summer heat buildup.

Structural recommendations

To prevent these structural problems, the home designer and builder should:

- ❒ Ensure that the footing is installed level and below the frost line. Use adequate reinforcing and make sure concrete has the proper slump and strength.
- ❒ Divert ground water away from the building through a properly designed and installed foundation drainage system and effective gutters, downspouts, and rain water drains.
- ❒ Build a quality roof and thorough exterior flashing to prevent rainwater intrusion. Install a "drainage plane" that sheds water outside (Figure 3-9).
- ❒ Seal penetrations that allow moisture to enter the building envelope via air leakage. Use firestopping sealants to close penetrations that are potential sources of "draft" during a fire. Install baffles in attics to prevent air from washing over insulation.
- ❒ Install a series of capillary breaks that keep moisture from migrating through foundation systems into wall and attic framing.

Figure 3-8
Bulk Moisture Transport

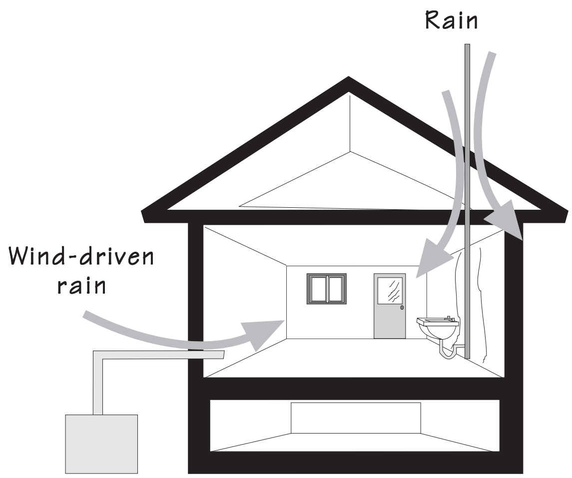
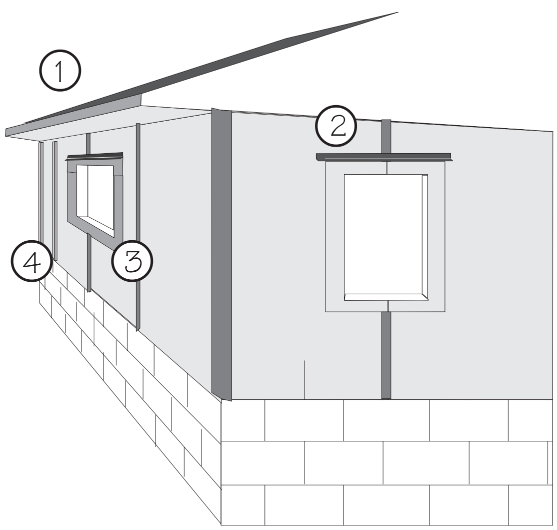


Figure 3-9
Drainage Plane



1. Design and build durable roof with modest overhang.
2. Carefully flash around windows, doors, and other openings.
3. Tape or caulk joints in foam sheathing to prevent rain or water penetration.
4. In homes with considerable rainfall, install furring strips between wall sheathing and siding to create a moisture-ventilating air space that allows water to drain.

Moisture Control System

Homes should be designed and built to provide comfortable and healthy levels of relative humidity. They should also prevent both liquid water and water vapor from migrating through building components.

An effective moisture control system includes quality construction to shed water from the home and its foundation, vapor and air barrier systems that hinder the flow of water vapor, and heating and cooling systems designed to provide comfort all year.

There are four primary modes of moisture migration into our homes. Each of these must be controlled to preserve comfort, health, and building durability.

Bulk moisture transport

- ❒ The flow of moisture through holes, cracks, or gaps
- ❒ Primary source is rain and groundwater
- ❒ Causes include:
  - poor flashing
  - inadequate drainage
  - poor quality weatherstripping or caulking around joints in building exterior (such as windows, doors, and bottom plates)
- ❒ To solve, install a building drainage plane:
  - no roof leaks; gutters connected to drain system carry roof water away from foundation
  - walls built with continuous drainage plane (see Figure 3-9)
  - high quality weatherstripping or caulking around joints in building exterior (such as windows, doors, and bottom plates)
  - all openings through wall — for windows, doors, plumbing, lighting, etc. — well flashed and sealed to prevent rain penetration
  - soil sloped away from home to divert ground water from foundation
  - foundation wall waterproofed and provided with a drainage system — gravel or a gravity-drain membrane
  - foundation drain, preferably located beside the footing, to carry water away from the house

Capillary action

❒ Wicking of water through porous materials or through small cracks.

❒ Primary sources are from rain or ground water.

❒ Causes include:

- ❍ water seeping between overlapping pieces of exterior siding
- ❍ water drawn upward through pores or cracks in concrete slabs
- ❍ water migrating from crawlspaces into attics through foundation walls and wall framing

❒ Solved by completely sealing pores or gaps, increasing the size of the gaps (usually to a minimum of 1/8 inch), or installing a waterproof, vapor barrier material to form a capillary break.

❒ The foundation system should include a drain pipe surrounded by a gravel bed covered by a filter fabric to prevent dirt from stopping up the gravel. In addition, install a layer of 10-mil polyethylene under concrete slabs and footings. Use sill sealer between concrete foundation walls and sill plates.

❒ Lapped siding should be primed on the back. In addition, the wall system should have an air space behind the siding and a continuous drainage plane behind the air space, such as 30-pound roofing felt installed shingle style.

Air transport

❒ Unsealed penetrations and joints between conditioned and unconditioned areas allow air containing water vapor to flow into enclosed areas. As shown in Figure 3-11, air transport can bring 50 to 100 times more moisture into wall cavities than vapor diffusion.

❒ Primary source is water vapor in air.

❒ Causes include air leaking through holes, cracks, and other leaks between:

- ❍ interior air and enclosed wall cavities
- ❍ interior air and attics
- ❍ exterior air and interior air, adding humidity to interior air in summer
- ❍ crawlspaces and interior air

❒ Solved by creating an Air Barrier System.

Figure 3-10
Capillary Action

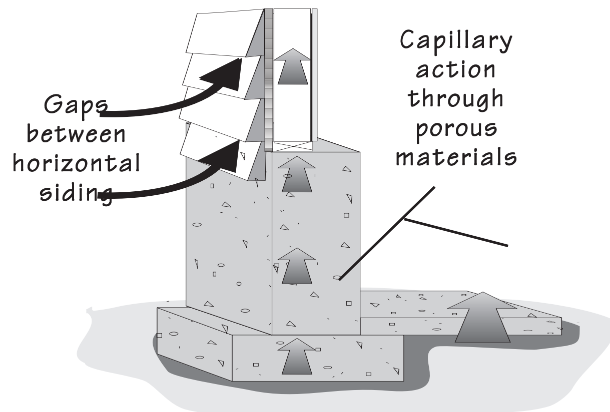
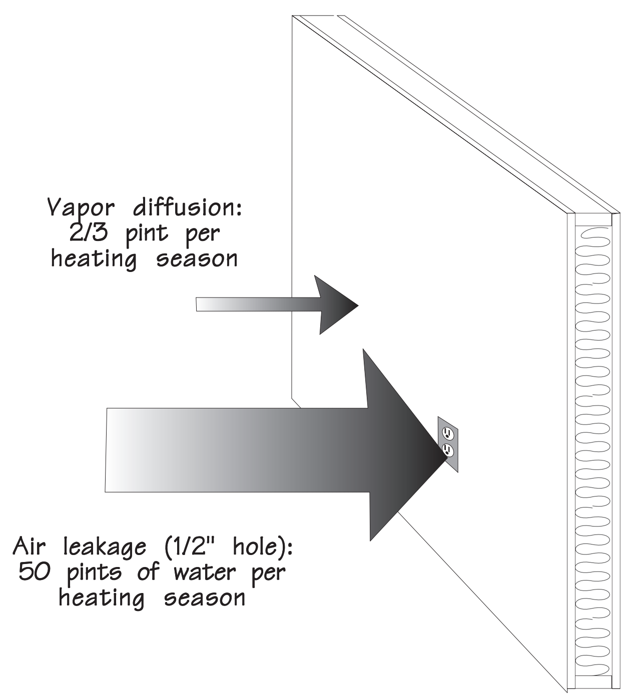


Figure 3-11
Typical Water Vapor Transport
(100 sq ft Wall Without a Vapor Barrier)



MOISTURE PROBLEM EXAMPLE

The owner of a residence complains that her ceilings are dotted with mildew. On closer examination, an energy auditor finds that the spots are primarily around recessed lamps located close to the exterior walls of the building.

What type of moisture problem may be causing the mildew growth, which requires relative humidities over 70%? In reality, any of the forms of moisture transport could cause the problem:

Bulk moisture transport — the home may have roof leaks above the recessed lamps.

Capillary action — the home may have a severe moisture problem in its crawlspace or under a slab. Via capillary action, moisture travels up the slab, into the framing lumber, and all the way into the attic. If the attic air becomes sufficiently moist, it may condense on the surface of the cool roof deck and drip onto the insulation and drywall below.

Air transport — most recessed lamps are quite leaky; if the air leaking into the attic is relatively warm and moist, and the roof deck is cool, the water vapor in the air may condense and drip onto the drywall. *This is the most likely explanation.*

Vapor diffusion — the home's ceiling may not have an adequate vapor barrier in the vicinity of the recessed lamps, resulting in excessive vapor flow into the attic. Although this situation is highly unlikely in Louisiana, the true cause may be a combination of the above problems.

Figure 3-12
Bulk Moisture Transport

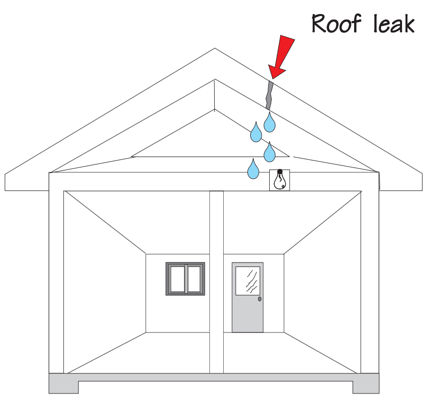


Figure 3-13
Capillary Action

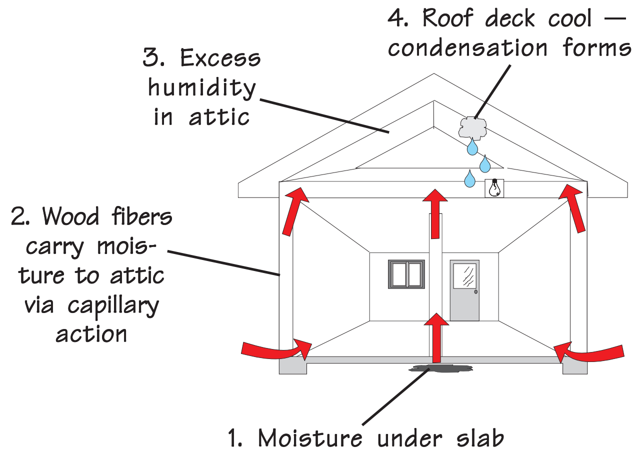


Figure 3-14
Air Transport

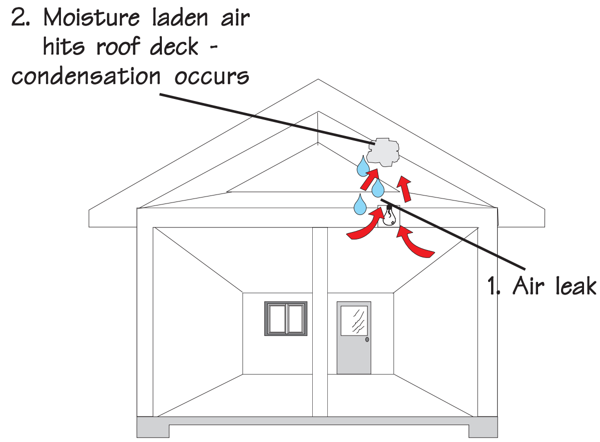
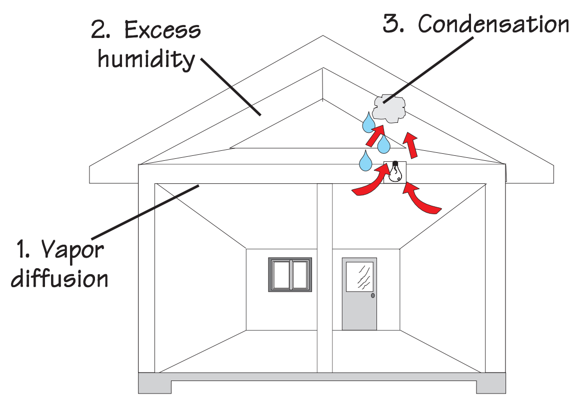


Figure 3-15
Vapor Diffusion



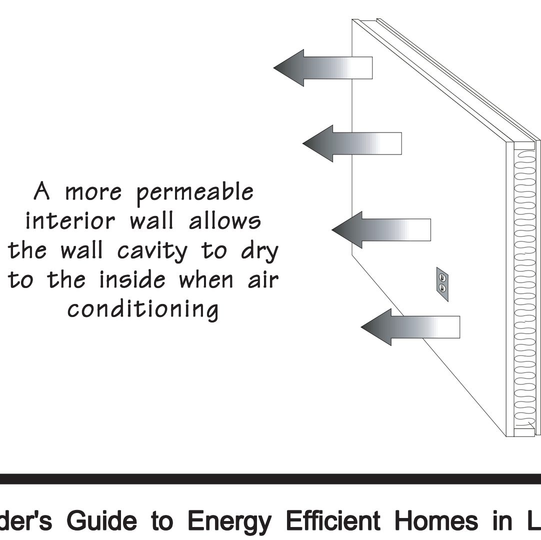
Vapor diffusion

- ❒ Water vapor in air moves through permeable materials — those with Perm ratings of over 1.
- ❒ Primary source is water vapor in the air.
- ❒ Causes:
  - ❍ interior moisture permeating wall and ceiling finish materials
  - ❍ exterior moisture moving into the home in summer
  - ❍ moist crawlspace air migrating into the home
- ❒ Solved by proper installation of a vapor barrier. However, interior vapor barriers are not recommended in Louisiana. Winters are mild so interior vapor barriers are not necessary; exterior sheathing materials usually serve as partial vapor barriers in summer. Wall systems without interior vapor barriers can dry to the inside of the home.

Table 3-2
Perm Ratings of Different Materials

Aluminum foil (.35 mil)	0.05
Polyethylene plastic (6 mil)	0.06
Plastic-coated insulated foam sheathing	under 0.30
Asphalt-coated paper backing on insulation	0.40
Vapor barrier paint or primer	0.45
Plywood with exterior glue	0.70
Drywall (unpainted)	50.0

Figure 3-16
Drying to the Interior



Air Barrier System

Air leakage can be detrimental to the long term energy efficiency and durability of homes. It can also cause many other problems, including:

- ❒ High humidity in summer and dry air in winter
- ❒ Allergy problems
- ❒ Radon entry via leaks in the floor system
- ❒ Mold growth
- ❒ Drafts
- ❒ Window fogging or frosting
- ❒ Excessive heating and cooling bills
- ❒ Increased damage in case of fire

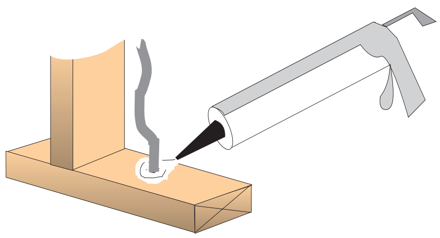
An air barrier system may sound formidable, but it is actually a simple concept — seal all leaks between conditioned and unconditioned spaces with durable materials. Achieving success can be difficult without diligent efforts, particularly in homes with multiple stories and changing roof lines.

Air barriers may also help a home meet local fire codes. One aspect of controlling fires is preventing oxygen from entering a burning area. Most fire codes have requirements to seal air leakage sites.

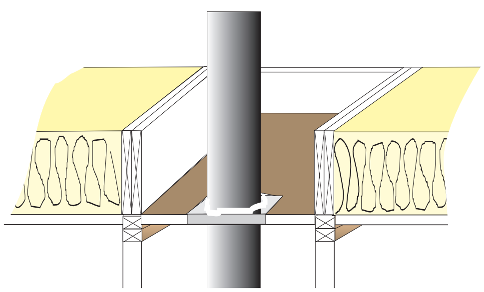
There are a number of air barrier systems — all can be effective with proper installation. They are one of the key features of an energy efficient home. The basic approach is:

- ❒ Seal all air leakage sites between conditioned and unconditioned spaces:
  - ❍ caulk or otherwise seal penetrations for plumbing, electrical wiring, and other utilities.
  - ❍ seal junctions between building components, such as bottom plates and band joists between conditioned floors.
  - ❍ consider using insulation that also air seals, such as foam or densely packed cellulose or rock wool.
- ❒ Seal bypasses — hidden chases, plenums, or other air spaces through which attic or crawlspace air leaks into the home.
- ❒ Install a continuous air barrier system such as the Airtight Drywall Approach or exterior housewrap that is vapor permeable and sealed properly.

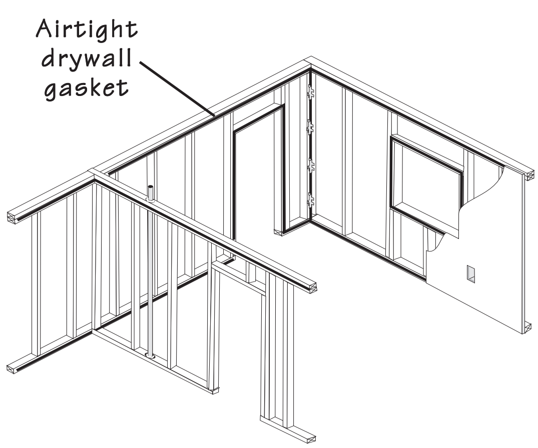
Figure 3-17
Air Barrier System Requirements



Seal all penetrations



Seal bypasses at attic floor and crawlspace/ unheated basement ceiling



Install continuous air barrier system

Thermal Insulation System

Thermal insulation and energy efficient windows are intended to reduce heat loss and gain due to conduction. As with other aspects of energy efficient construction, the key to a successfully insulated home is quality installation.

Substandard insulation not only inflates energy bills, but may create comfort and moisture problems. Key considerations for effective insulation include:

- ❑ Install R-values equal to or exceeding the 2000 International Energy Conservation Code.
- ❑ Do not compress insulation.
- ❑ Provide full insulation coverage of the specified R-value; gaps dramatically lower the overall R-value and can create areas subject to condensation.
- ❑ Prevent air leakage through insulation — in some insulation materials, R-values decline markedly when subject to cold or hot air leakage.
- ❑ Air seal knee walls and other attic wall areas and insulate with a minimum of R-19 insulation.
- ❑ Support insulation so that it remains in place, especially in areas where breezes can enter or rodents may reside.
- ❑ Consider installing a radiant heat barrier; especially in homes whose roofs receive sunlight in the summer and have less then R-30 insulation.

Comfort Control System

The heating, ventilation, and air conditioning (HVAC) system is designed to provide comfort and improved air quality throughout the year, particularly in winter and summer. Energy efficient homes, especially passive solar designs, can reduce the number of hours during the year when the HVAC systems are needed.

These systems are sometimes not well designed nor installed to perform as intended. As a consequence, homes often suffer higher heating and cooling bills and more areas with discomfort than necessary. Poor HVAC design can also lead to moisture and air quality problems.

One major issue concerning HVAC systems is their ability to create pressure imbalances in the home. The sidebar on the next page shows that duct leaks can create serious problems. In addition, even closing a few doors can create situations that may endanger human health.

Pressure imbalances can increase air leakage, which may draw additional moisture into the home. Proper duct design and installation helps prevent pressure imbalances from occurring.

HVAC systems must be designed and installed properly, and maintained regularly by qualified professionals to provide continued efficient and healthy operation.

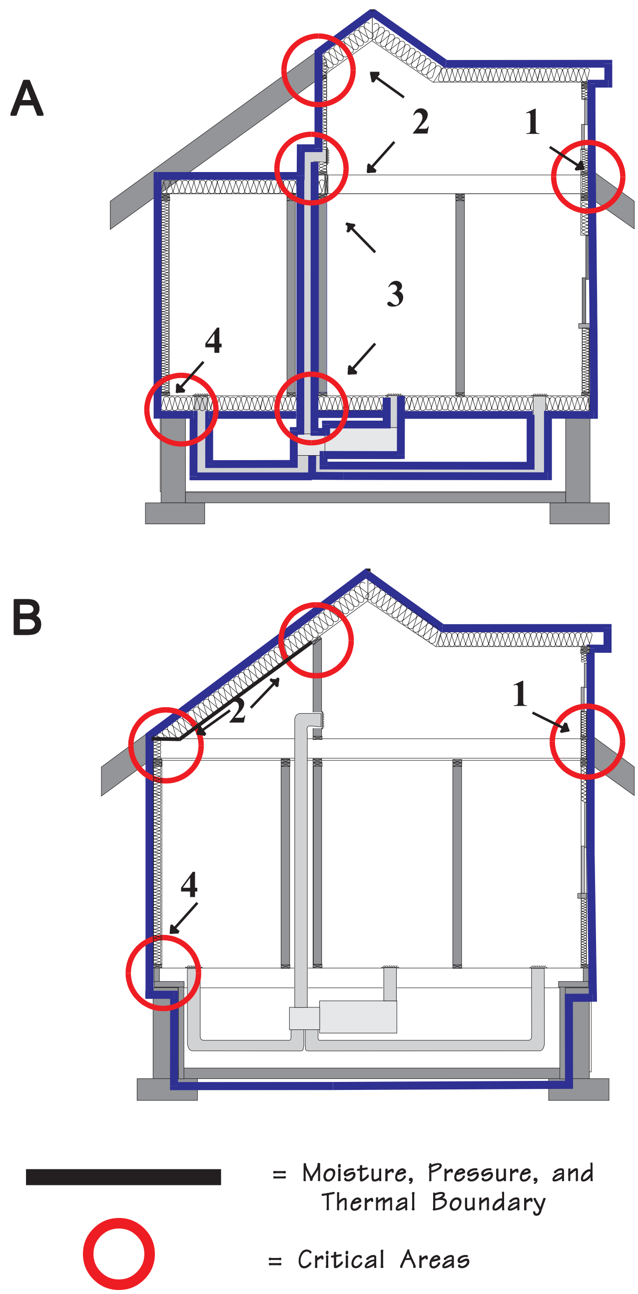
Creating Boundaries

In the field of building science, the term boundary has been applied to an external barrier created to control moisture, air leakage, and thermal conduction losses and gains. Every successful energy efficient home should have a moisture boundary, air leakage (pressure) boundary, and thermal boundary that separate unconditioned areas of the home from areas with heating or cooling.

In Figure 3-18, two different boundaries are shown for homes identical in shape and size. The boundary in Figure 3-18A, which depicts standard construction, is smaller than the boundary in Figure 3-18B. However, it is also more complicated. Boundary B is simpler because it incorporates virtually the entire home's exterior. One advantage of Boundary B is that the ductwork is all located within the sealed insulated envelope of the home. In Boundary A, the ducts must be sealed and insulated as they are part of the boundary.

The designer and builder must direct the subcontractors about how to install continuous air and ductwork sealing materials, insulation, moisture retarders, drainage systems, and other building materials. The air quality and durability of a home depend vitally on how well these boundaries are installed and maintained.

Figure 3-18
Residential Boundaries



Critical Area Identifiers

1 Band joists and intersections with shed roofs
2 Joints between attic and conditioned space
3 Tops and bottoms of chases
4 Other critical areas not in the diagrams include stairwells, bonus rooms over garages, cantilevered floors, dropped framing over cabinets and shower-tub units, and fireplaces

DUCT LEAKS AND INFILTRATION

Forced-air heating and cooling systems should be *balanced* — the amount of air delivered through the supply ducts should be equal to that drawn through the return ducts. If the two volumes of air are unequal, pressure imbalances may occur in the home, resulting in increased air leakage and possible health and safety problems.

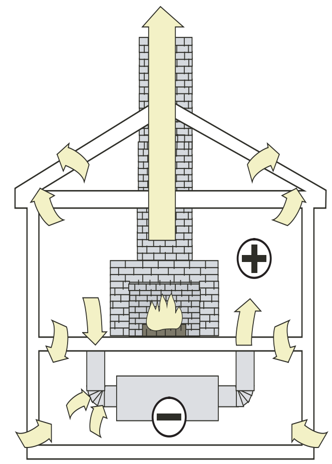
If **supply ducts** in unconditioned areas have more leaks than return ducts:

- ❒ Heated and cooled air will escape to the outside, increasing energy costs.
- ❒ Less air volume will be "supplied" to the house, so the pressure inside the house may become negative, thus increasing air infiltration.
- ❒ The negative pressure can actually *backdraft* flues — pull exhaust gases back into the home from fireplaces and other combustion appliances. The health effects can be deadly if flues contain substantial carbon monoxide.

If **return ducts** in unconditioned spaces leak:

- ❒ The home can become pressurized, thus increasing air leakage out of the envelope.
- ❒ Hot, humid air is pulled into the ducts in systems in summer; cold air is drawn into the ducts in winter.
- ❒ Human health may be endangered if ducts are located in areas with radon, mold, or toxic chemicals from soil termite treatments, paints, cleansers, and pesticides.

Figure 3-19
Balanced Air Distribution



- ❒ If combustion appliances are located near return leaks, the negative pressure created by the leaks can be great enough to backdraft flues and chimneys.

Pressure differences can also result in homes with tight ductwork if the home only has one or two returns. When interior doors are closed it may be difficult for the air in these rooms to circulate back to the return ducts. The pressure in the closed-off rooms increases, and the pressure in rooms open to the returns decreases.

Installing multiple returns, "jumper" ducts or transfer grilles that connect closed off rooms to the main return, and undercutting doors to rooms without returns will alleviate these problems.

Figure 3-20
Air Leaks in Supply Ducts

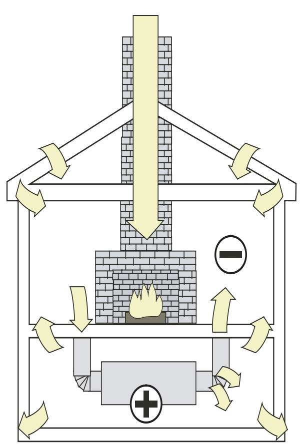


Figure 3-21
Air Leaks in Return System

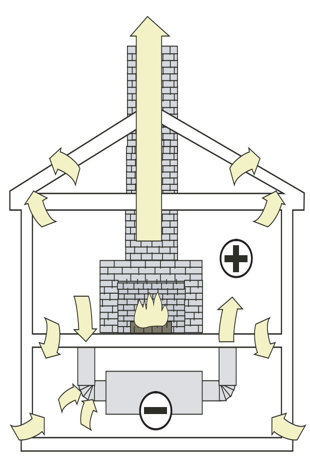
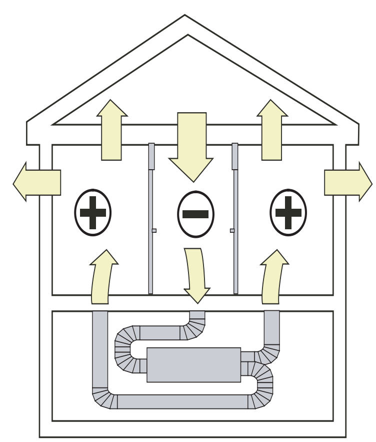


Figure 3-22
Return Blocked by Door



WALL MOISTURE EXAMPLE

The two examples on the following pages describe building science problems due to common failures of the home's systems. These problems can be minimized through careful attention to the construction techniques described in this publication.

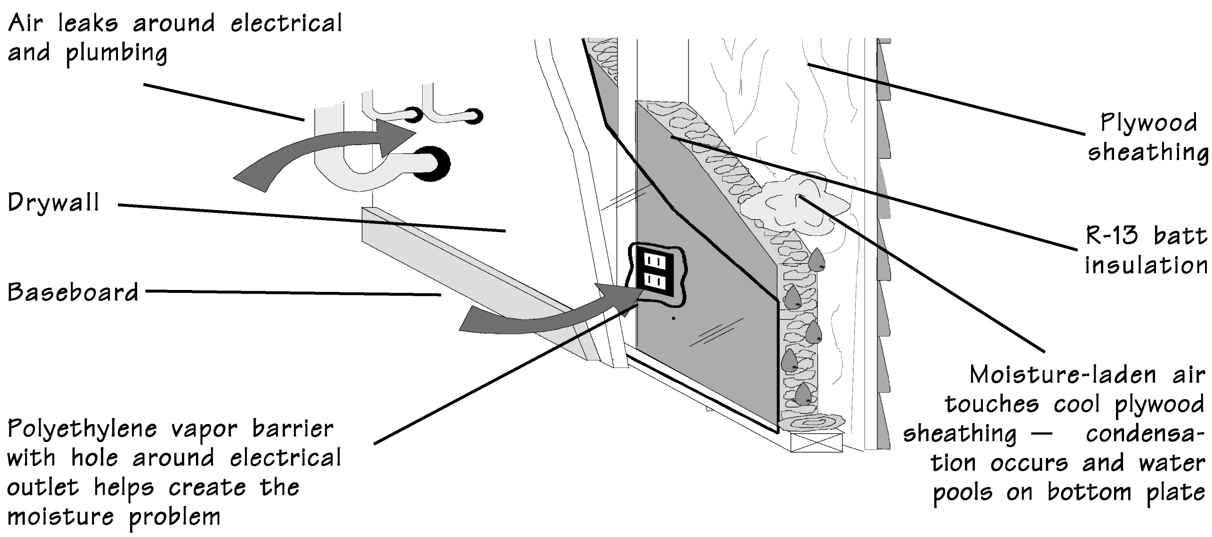
A homeowner in Shreveport notices that paint is peeling on the exterior siding near the base of a bathroom wall. The drywall interior has mildew and the baseboard paint is peeling as well. What happened?

1. The interior of the wall has numerous air leaks — an air barrier system failure.
2. The door to the bathroom is usually closed. When the heating and cooling system operates, the room becomes pressurized, as it has no return and its door is not undercut at the bottom. This is an HVAC system failure.
3. The bath fan is installed improperly and does not exhaust moist air — another HVAC system failure.
4. When air leaks into the wall, it carries substantial water vapor, thus the failure of the air barrier and HVAC systems have led to a moisture control system failure.
5. The interior wall has a polyethylene vapor barrier, which is not an air barrier because it is not fully sealed to the outlet box, bottom and top plates, rough openings, and other penetrations. The exterior has CDX plywood sheathing, which is a vapor barrier.
6. When the air leaks carry water vapor into the wall cavity, the interior and exterior vapor barriers hinder drying — a moisture control system failure.
7. In winter, the inner surface of the plywood sheathing will be several degrees cooler than foam sheathing would have been. Thus, the plywood-sheathed wall has more potential for condensation — an insulation system problem.
8. As the water vapor condenses on the sheathing, it runs down the wall and pools on the bottom plate of the wall. Now the following problems occur:

- ❒ The water threatens to cause structural problems by rotting the wall framing.
- ❒ It wets the drywall, causing mold to grow.
- ❒ It travels through the unsealed back surfaces of the wood siding and baseboard, causing the paint to peel when it soaks through the wood.
- ❒ The multiple failures of the building systems create a potential structural disaster.

To solve this moisture problem the builder must address all of the failures. If only one aspect is treated, the problem may even become worse.

Figure 3-23
Wall Moisture



CARBON MONOXIDE DISASTER

1. A home has been built to airtight specifications — an air barrier system success.
2. However, the home's ductwork was not well sealed — a HVAC system failure. It has considerably more supply leakage than return leakage which creates a strong negative pressure inside the home when the heating and cooling system operates.
3. The homeowners are celebrating winter holidays. With overnight guests in the home, many of the interior doors are kept closed. The home has only a single return in the main living room.
4. When the system operates, the rooms with closed doors become pressurized, while the central living area with the return becomes significantly depressurized. Because the house is very airtight, it is easier for these pressure imbalances to occur.
5. The home has a beautiful fireplace without an outside source of combustion air. When the fire in the unit begins to dwindle, the following sequence of events could spell disaster for the household:

- ❒ The fire begins to smolder, producing increased carbon monoxide and other harmful pollutants.
- ❒ Because the fire's heat dissipates, the draft pressure, which draws gases up the flue, decreases.
- ❒ The reduced output of the fire causes the thermostat to turn on the heating system. Due to duct pressures and closed interior doors, the blower creates a relatively high negative pressure in the living room.
- ❒ Because of the reduced draft pressure in the fireplace, the negative pressure in the living room causes the chimney to backdraft — the flue gases are drawn back into the home. Backdrafting may generate considerable carbon monoxide and cause severe, if not fatal, health consequences for the occupants.

This example is extreme, but similar events occur in dozens of Louisiana homes each year. The solution to the problem is not to build leaky homes — they can experience similar pressure imbalances. Instead, eliminate the causes of pressure imbalances and install an external source of combustion air for the fireplace as well as a carbon monoxide detector.

Figure 3-24
Carbon Monoxide Disaster